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ABSTRACT

This paper explores the process of writing from several perspectives, as a first step toward a more comprehensive theory. The first perspective sees writing as a communicative act. The observation that to write is to communicate, though commonplace, has major and sometimes surprising implications for a theory of writing. It forces a focus on the active role of the reader and leads to an emphasis on the audience in choosing tasks for beginning writers. The second perspective sees writing in the context of a taxonomy of communicative acts. Differences between writing and conversing, writing and lecturing, writing a play and writing a story have important theoretical and practical implications. The third perspective focuses on writing as a decomposable process whose product must still fulfill an overall communicative function. To this end, various subprocesses of writing are sequentially analysed, including discovering and manipulating ideas and generating text at different structural levels. (Author/AA)

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A COGNITIVE SCIENCE APPROACH TO WRITING

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> The poet's trade, the writer's trade, is a strange one. Chesterton said: "Only one thing is needful - everything."
> J.L. Borges

1. Introduction

What is Writing? A child in school might say that writing is an exercise to improve penmanship; that it is an extension of talking to oneself; or that it is conversation written down. Poets, linguists, literary analysts and rhetoricians have likewise given their definitions of writing. Perhaps writing is difficult to define because it cannot be separated from thinking, creating, or even from life experiences. As an act of communication it involves both a writer and a reader, as well as words on a page. To be a writer, one needs to take all of this into account; as Chesterton said, everything is relevant.

In the midst of this complexity people still need to know answers to some specific questions about writing: How do children learn to write? Why do some people have difficulties in writing well? What is the best way to teach writing? Can there be a theory of good writing? Questions such as these define the goals of our inquiry.

But where do we begin in the analysis of a process as complex as writing? Rather than attempting a global analysis, we have taken three perspectives, or flashlights, which we hope will illuminate enough of what writing is all about that we can formulate tentative answers to some of the questions posed above. The advantage of a flashlight is that it highlights only certain aspects of the process, allowing us to concentrate on those and ignore the rest,

which remain in darkness. The result of such an analysis, then, is not a coherent and unified theory of writing, but rather some new insights into the process from several perspectives, and new sets of questions whose answers would contribute to a more comprehensive theory.

With our first flashlight, we see writing as a communicative act (Section 2). The observation that to write is to communicate, though commonplace, has major, and sometimes surprising, implications for a theory of writing. It forces us to focus on the active role of the reader and leads us to an emphasis on the audience in choosing tasks for beginning writers. With our second flashlight, we see writing in the context of a taxonomy of communicative acts. In Section 3 we explore the differences between writing and conversing, writing and lecturing, writing a play and writing a story and spotlight the important theoretical and practical implications of these differences. Our third flashlight focuses on writing as a decomposable process whose product must still fulfill an overall communicative function (Sections 4-8). To this end, we train the flashlight sequentially on various subprocesses of writing - discovering and manipulating ideas and generating text at different structural levels. The analysis is only an initial attempt to specify the elements of a process theory of writing, a theory which will evolve from questions suggested by this process-oriented view.

These three perspectives allow us to begin to formulate answers to some of the questions posed above. In terms of teaching writing, they lead us to search for tasks which, although they are less

complex than writing a story from start to finish, still maintain the primary function of language - to communicate to an audience (see Sections 9 and 10). To take an over-simple example, we would prefer the task: "Write a funny sentence using the word 'banana'" to the task: "Write 5 sentences each using the word 'banana'" because the former takes into account an audience who might laugh at the sentence.

Another implication for education follows directly from viewing writing as a process composed of subprocesses. Teaching people to separate the various task components allows them to learn how to use the most effective generation strategies for each subprocess, how to edit with respect to each subprocess, and how to ignore other constraints while working on a subprocess (Flower & Hayes, in press). People who write a lot develop many of these techniques in the course of their experience, but they are not usually taught to children explicitly and must be learned in a painful trial and error fashion. Yet, knowing techniques is clearly not sufficient for good writing, since a technique for achieving one communicative goal may interfere with the achievement of another. For example, the introduction of humor may strengthen the hold on the reader's interest, while simultaneously lessening the reader's respect for a position being argued. Our discussion of writing as a communicative act with explicit goals provides a preliminary language for discussing these interactions.

Equally important for a theory of writing and for teaching writing is a theory of the text-structure constraints operating in fluent writing. Such a theory would be a theory of <u>good</u> structures

rather than of well-formed structures. Most theories heretofore have concentrated on defining well-formedness. For example, a syntactic grammar attempts to specify the set of well-formed sentences (cf. Chomsky, 1958) and a story grammar attempts to specify the set of well-formed stories (cf. Rumelhart, 1975). But books on how to write (cf. Strunk & White, 1972; Hall, 1973) specify a different class of constraints on sentence, paragraph, and text structures; constraints designed to make texts more readable and memorable. The good structures fitting these constraints are in general a subset of the set of well-formed structures. Our focus on the subprocesses of writing and the structural levels of text provides a framework for defining effective text structures.

Finally, a theory of writing should provide a description of where the major difficulties arise in the process. Insights into these difficulties arise from a consideration of the differences among various language experiences and the more demanding cognitive skills writing entails. We provide here some characterization of the problems most often experienced by beginning writers, as well as some techniques for surmounting these problems.

2. Writing as a Communicative Act

One might think of writing as a process whereby one person "moves" ideas from his or her mind into the mind of another. Such a view, often called the "transportation metaphor", appears plausible at first glance. It conjures up phrases from mathematical information and communication theory such as "the rate of information transfer", which in turn suggest that writing is

basically "transferring ideas to paper." Reading is then a process of recovering the information in the text. If the channel is not too "noisy", then the ideas will have moved successfully from one mind to the other.

That the transportation metaphor is hopelessly inadequate can be seen from a consideration of two points, one related to the writer, the other to the reader. The first point is that ideas necessarily evolve with the production of text. What seem to be three good points initially become two, or four, when they must be expressed in words. The need to connect ideas causes connecting ideas to be produced. Words themselves stimulate idea production. These phenomena are central, not just incidental, aspects of the activity of writing. Thus the ideas we "move" to the paper come into existence during and because of the act of moving them.

The second point is that the supposed channel for information from the writer to the reader is worse than unpredictably noisy. The reader plays an active role in determining what information is to be transferred and may read not only between the lines, but entirely outside them. Information never intended to be communicated can be "understood" by the reader. Knowing that the reader is an active participant should and does suggest to the good writer a concern for how the text will be read, not just how it is written. The writer must, in effect, take the position of the reader, and interpret the text as the imagined reader would. This means that the writer has to apply his or her beliefs about how the reader will construct a model of the text's meaning. Where the meaning would become unclear, the writer must re-write, taking into

account how the imagined reader might be straying down the wrong path. This constraint on writing is, of course, impossible to apply perfectly for one reader, much less for all readers. In fact, one of the most difficult aspects of writing, especially for beginners, may be the necessity to address an unknown and non-individual audience (see Bruce, 1977 for a discussion of this issue as it applies to reading).

Rejection of the transportation metaphor widens the scope of questions a writer should be concerned with, but also makes possible better writing. Fox example, a writer should consider that a correct idea, well expressed, may still fail to achieve the writer's purpose. The writer needs to ask questions such as the following:

-Is the form of text (e.g., parody, argument, fable) appropriate to the function it is expected to serve?

-Will the imagined reader be affected in the desired way?

-Are simultaneous functions (e.g., humor and information) being served?

-Does each structural level achieve its purpose?

In an effort to make this analysis more focused, we have identified four principles that form tacit objectives in any communicative act. In writing, these objectives are realized by different structures and devices at different levels of a text. There are sometimes other objectives, such as making a text legally unambiguous, but these four appear to have the greatest generality.

Comprehensibility - An important objective in writing is to make the text as easy as possible for the reader to understand. What the

writer must do is to give the reader enough clues to construct the correct model of the text. Some strategies that increase comprehensibility are the following: using examples to illustrate general principles, filling in intervening steps in arguments, and using short, simple sentences.

Enticingness - If a reader gets bored and puts aside a text before finishing it, its comprehensibility is irrelevant. Therefore, it is important to use various devices to hold the reader's attention. In conjunction with this, it is sometimes wisest to include the most important information in the beginning, in case the reader stops reading for some reason. There are a variety of devices designed to accomplish this objective: pyramid text form, the use of suspense or humor, and entrapping the reader emotionally with the characters.

Persuasiveness - Commonly in expository texts, the goal is not only to explain some set of ideas, but also to convince the reader the ideas are true (Martin & Ohmann, 1963). There are a number of devices used to make texts more persuasive: the argument form used in some texts, admission by the writer of any problems or limitations, the detailed description of methods used, and the invocation of authoritative opinion.

Memorability - An important principle, particularly for expository writing, is to structure the writing so that the reader can hold the essential parts of the text in memory. This quality, which we call memorability, goes beyond ease of understanding. A text can be easy to understand, but not very memorable; magazine articles, for

example, are often highly readable but nearly impossible to remember after a few days.

Memorability is achieved in a number of ways at different levels of text. Using structures that are easy to remember, such as tree structures, lists, and tables, is one important means. The use of headings and statements about the structure of the text also help the reader organize the material to remember the key points. Experiments by Meyer (1975) and Thorndyke (1977) have shown how different structural aspects of text affect people's ability to remember it.

The view of writing as a communicative act between the writer and the reader, rather than as idea transportation, leads to a number of research questions:

-How much do writers differ in their implicit use of a model of the reader?

-Can a beginning writer be taught to think of the text from the perspective of a typical reader?

-How does writing differ from other communicative acts?

-What techniques are available to a writer to avoid having to simulate the imagined reader at every step?

-How can idea production and text production be integrated?

-How can a writer evaluate the text with respect to its purpose, given that ideas cannot just "be" in the text?

3. Writing and Other Language Experiences

There are many inherently different language experiences, from reading comics to listening to a lecture, from writing a letter to talking with friends, from watching a play to writing a novel. Each of these places different demands upon the participants, differences which account for some of the specific difficulties experienced in various media. In particular, we cannot fully understand writing until we understand its relationship to the oral language experiences upon which children's linguistic knowledge is based. The differences between this experience and writing fall into two major categories: those having to do with the communicative medium and those having to do with the message. We give a sketch here of the significance of these differences (see Rubin, 1978, for further details).

With respect to communicative medium, there are at least seven dimensions along which language experiences can vary. The contrasts are made between the experiences, not just the vehicles for the message: for example, between being in a conversation and writing a story, rather than between a conversation and a story. In terms of the seven dimensions, a person's oral language experience lies at one extreme and writing a story at the other. The dimensions are the following:

Interaction - A person in a conversation can ask and be asked questions. A writer, on the other hand, must ensure that the message will be understood without such interaction. There are thus much greater demands on his or her model of the reader.

Involvement - In conversation each participant talks to the others. Writing is only occasionally directed to a specific person: it is sometimes directed to someone other than the reader; and characters in a written story direct their dialogue to each other, not the reader. These are major complications for the person just learning to write.

Modality - The techniques used in speech for emphasis, clarification, etc. are often unavailable to the writer. For example, the sentence, "Mary brought the cider", could mean, "It was Mary who brought the cider" or "It was the cider Mary brought." In speech, one would use stress to accomplish the same function that the relative clause construction serves in writing.

Spatial Commonality - When writing, one does not have the benefit of a shared spatial context which allows the use of extralinguistic communication such as gestures and facial expressions and easy reference to directions and places, e.g., "here" and "there".

Temporal Commonality - Similarly, a writer must work with the fact that the reader will be reading the material at a time different from when it was written.

Concreteness of Referents - A writer cannot take advantage of the shared visual presence of objects and events, e.g., "this bowl", "that window". Descriptions of such objects must be built up step by step, rather than perceived all at once.

Separability of Characters - The writer must use linguistic devices to make distinctions among different people's statements and points of view; in conversations, the source of each utterance is more immediately clear.

Writing a story differs from the typical oral language experience in that there is no interaction between the sender (writer) and the receiver (reader) of the story; the message cannot be directed to one reader; the modality is text, not speech: the reader and writer do not share a spatio-temporal context; and the writer must make a special effort to maintain the distinction among different people's statements and points of view. Some of these differences are illustrated in Figure 1. The boxes represent language experiences and the arrows between the boxes show the dimensions of variation. The center box, labeled "KID", represents a child's typical oral language experience. Following the arrows, one can see that "writing a play" or "writing a story without pictures" is maximally removed from the KID experience, and hence, presumably, from the skills the child is most familiar with.

The disparity (as communicative media) between a child's typical oral conversation and writing accounts in part for difficulties in learning to write. But the experiences also differ in terms of message. While conversations often wander from subject to subject, good texts have a topical coherence wherein each sentence gives necessary information about characters, situations, plot, or argument. The purposes of participants in conversations are also often ill-defined. They can change rapidly depending upon

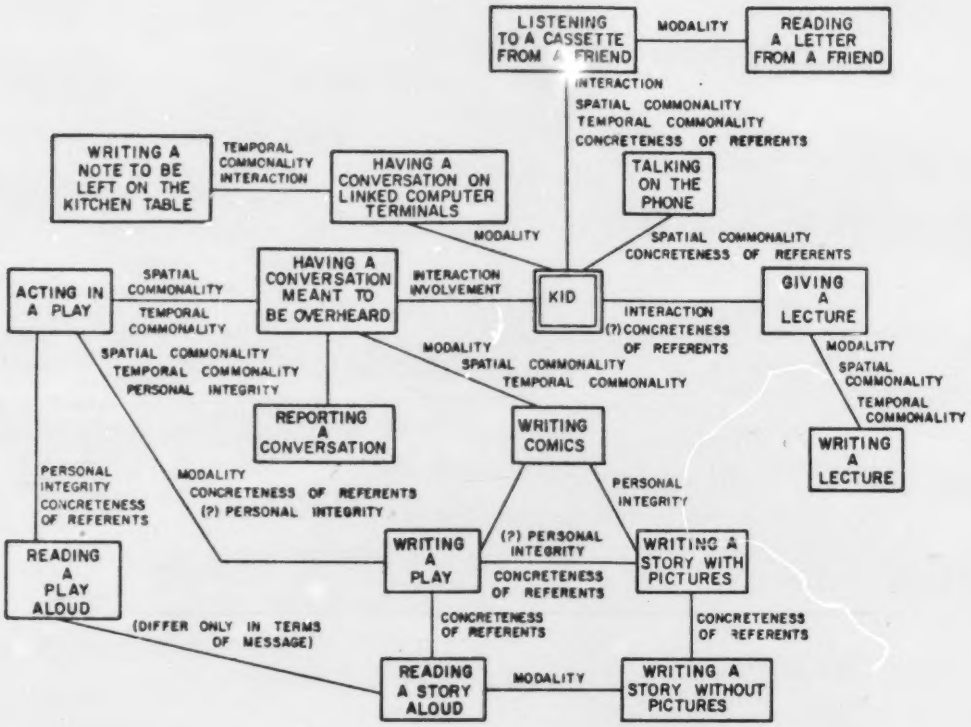

Fig. 1. Differences among language experiences as communicative media. The box labelled "KID" represents a child's typical oral language experience, while the other boxes show experiences that differ along one or more dimensions.

the utterances of other participants or upon events in the situation. Texts, on the other hand, require themes to be integrated to serve a sustained purpose. These differences need to be explored if we are to build a theory of writing or to understand the development of writing skills.

4. A Process Model of Writing

With the perspectives given above in mind, we now examine the process by which a piece of text is constructed (see Figure 2). W.H. Auden remarked that he always went about with two notions in his head: an idea seeking a form and a form seeking an idea. When these notions came together he could produce poetry. We would like to examine the processes that create the ideas and the forms, or structures, that make writing possible. Though these processes may occur simultaneously and interactively, a good way of understanding them is as separate steps in a procedure. The purpose of the procedure is to create a text that satisfies a variety of constraints, coming from three sources: text structure (what are good sentence forms, paragraph forms, and text forms), content (what ideas are to be expressed and how are they related), and purpose (how does the writer want to affect the reader and what is his or her model of the reader). Trying to satisfy all these constraints at once makes writing difficult, often leading to "writing block" in adults and children.

The processes of idea production and text production differ in fundamental ways. While the final text must be a linear sequence of words, the result of the process of idea production is a set of

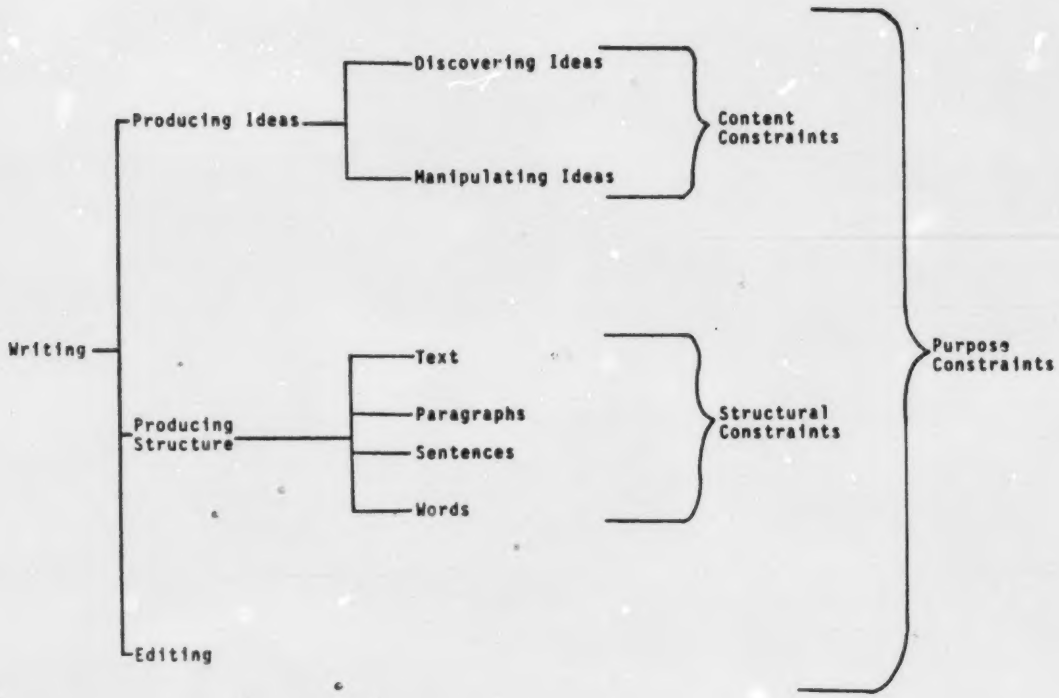

Fig. 2. Analysis of the Writing Process.

ideas with many internal connections, only a few of which may fit the linear model desirable for text. Although the set of ideas generated is subject to rules of logical consistency, plausibility and relevance, these rules are traditionally less codified than the rules for text production, and the number of allowable relationships between ideas is greater than the number of allowable relationships between elements of text. This difference is reflected in the fact that advice given for idea production usually has a free-style quality to it: people are advised to brainstorm, to use adventurous thinking, or to employ synectics (Bartlett, 1958; Flower & Hayes, in press), while advice for text production is more structured and rule-oriented.

In the next four sections we discuss first, the production of ideas; second, the production of text; third, devices for producing good texts; and fourth, editing both ideas and text to meet communicative goals.

5. Idea Production

At least two different subprocesses are involved in idea production: discovering ideas and manipulating ideas. Separating the different subprocesses allows a writer to apply systematic generation and editing strategies for each process. We describe below some strategies that are most effective for exposition, but that can be applied to other forms of writing as well.

The two substeps of idea production are illustrated in Figures 3 and 4. The figures describe the writing of this paper. Figure 3 shows some of the ideas we collected (but did not necessarily use),

Fig. 3. Collecting ideas. The figure shows some of the ideas and experiences of the authors during the early part of the writing of this paper.

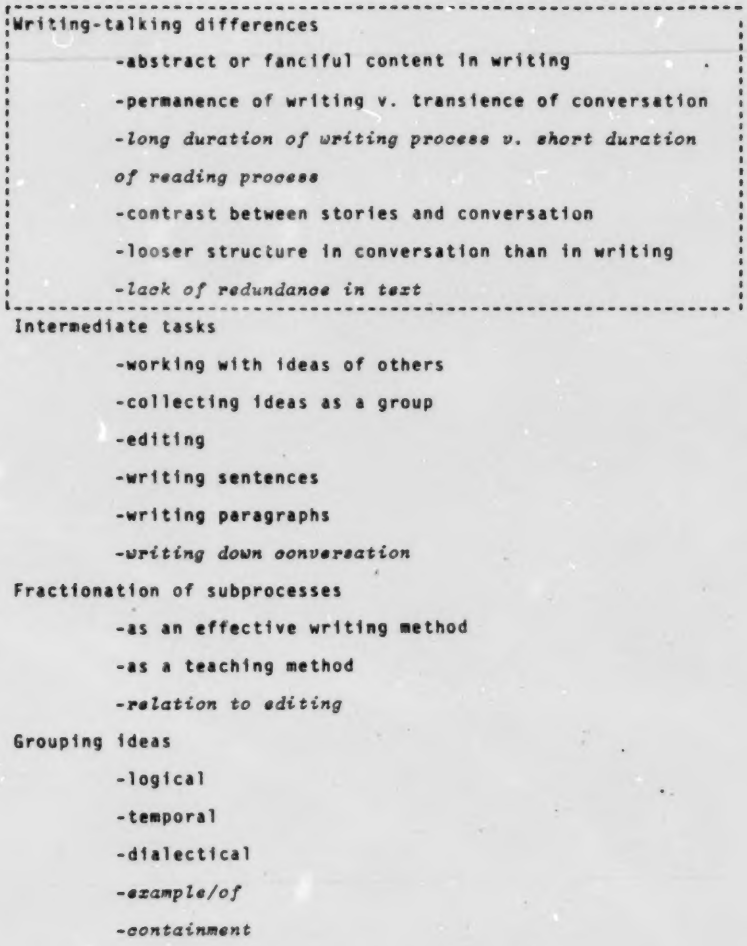

Fig. 4. Manipulating ideas. Ideas from Figure 3 are put in tentative groups, which, in turn, suggest new ideas (in italics). The outlined group of ideas corresponds to the section of text that is expanded in Figure 5.

while Figure 4 shows the manipulation of some of the ideas. Throughout, the generation of ideas was subject to content constraints, which were in turn modified by purpose constraints. For example, our intention in Section 3 of the paper was to emphasize aspects of writing that have implications for learning to write. This purpose modified content constraints, which specified that the differences between writing and talking were to be discussed, in the direction of more detail on medium differences.

Some of the questions suggested by this view of idea production are the following:

-What are the different ways people collect ideas (e.g., writing down random thoughts, writing down remarks of others)?

-How much can one focus the collecting process?

-Can collecting ideas be done as a group project?

-What are the different strategies people use for idea generation (e.g., compare and contrast)?

-What strategies are used for representing and writing down the ideas that are formulated (e.g., categories and lists, random collections, boxes and arrows)?

-What are the different ways people group ideas?

-What relations define groups (e.g., temporal, logical, example-of, subsumes, antithesis)?

5.1 Discovering Ideas

Fortunate indeed would be a writer whose ideas were always crisp and full developed. He or she could then concentrate every bit of energy on developing structures to express those ideas. Most

of us soon learn that that writer is someone else. We resign ourselves to the possibility of change in our ideas as we try to formulate them. Writing becomes both a thinking and an expressive activity. Van Nostrand's "functional writing" (Van Nostrand, Knoblauch, McGuire, & Pettigrew, 1977) is a good example of a curriculum which recognizes this unity of creative thinking and writing.

This approach to writing is altogether natural and effective, yet the process of discovering ideas is often omitted in discussions of writing. In our model of writing, it is an integral part. Whether we call it "creating", "discovery", "collecting" or "catching" it is probably best characterized by example, and by examples of methods to do it. It is the process of observing with a trained eye, of gathering data that can be used at some unforeseen time. Figure 3 shows some of the collecting that preceded the writing of this paper. Experience with computer modelling of conversations, for instance, provided us with data potentially relevant to the writing process. The data was, however, neither well formulated nor connected to other data in a useful way.

The format of Figure 3 is intended to emphasize this relative formlessness of ideas at the collecting stage. There are, nevertheless, some constraints that apply, even at this stage. Each of the ideas is evaluated for its relevance to the subject matter, writing. An example of this is the evolution of the idea that a reader's task is that of constructing a model of a story, to the idea that the writer's task is to supply the reader with sufficient cues to build that model. The impetus for this transformation is

the writer's desire to view the original insight from the perspective of the writing process.

One of the simplest yet most important strategies for writing on a given topic is to write down all the ideas that are related to the topic. It is important to do this before imposing a text structure, in order to include as relevant as many ideas as possible. (Flower & Hayes, in press).

Other systematic strategies for discovering ideas include:

(a) Free associating on the topic.

(b) Keeping a journal of relevant ideas and events.

(c) Brainstorming with a group.

(d) Looking in books (source materials).

(e) Getting suggestions from a teacher, parent or friend.

Essential to all these strategies is getting the ideas down in tangible form, so that they are ready for idea manipulation, the next stage.

5.2 Manipulating Ideas

The beginning of imposing structure on a set of ideas is to put the ideas into groups, combining small units into successively larger ones. The groups themselves become stimuli for further ideas (as shown in Figure 4). To stimulate as many additional ideas as possible, the writer should try various groupings, noticing any systematic patterns that occur.

Our goal in constructing a theory of idea production is to identify the strategies appropriate to different subprocesses and to specify when particular strategies should be used. In general,

these strategies for writing are not carried out in a strict order. In fact writers often use one step as a stimulus to the others. Some writers, for instance, write down as many ideas as possible in no particular order, under the assumption that groups will emerge. Others define groups first in order to facilitate the production. In either case, the processes of idea collection and idea manipulation are interleaved, each providing material for the other to work on.

There are various strategies for systematically grouping ideas. Most of them operate so as to generate new ideas as well as structuring the original ideas. We can illustrate this with two types of structuring strategies:

Compare and Contrast: Here the writer juxtaposes ideas in order to notice their similarities and differences, looking for analogies that underlie similar cases, and for explanatory principles that produce the similarities and differences. For example, if a writer is trying to describe the experience of eating a banana he or she will notice it is not as squashy or tangy as an apricot, nor as crisp as an apple, nor as stringy as meat. By systematically exploring the space of foods, he or she will think of most of the dimensions in which to describe how a banana tastes.

Taxonimize, Dimensionalize, Componetialize: Another effective strategy is to try to find ways of listing the ideas to form a taxonomy. For each list the writer should then look to see if there is an underlying dimension or dimensions that imposes structure on the list. If there is a dimensionalized space underlying the ideas,

then it may be possible to see the explanatory principles which structure the space. Furthermore, if there are any missing points or cells, a new idea corresponding to that cell can be generated and checked for plausibility. In this way structuring ideas generates new ideas.

An example of the effectiveness of this strategy is the development of the periodic table in chemistry. Before the discovery of the periodic table, the chemical elements merely formed groups of similar entities. Mendeleyev's discovery of the two-dimensional structure of the elements led to the discovery of new elements which filled missing cells in the structure, and to the discovery of the atomic model which yields some explanatory principles underlying the organization of the table.

6. Text Production

In order to produce text, it is necessary to impose text structures on the ideas. Text structures occur at different levels. The longer the text, the more such levels there are. For simplicity, we will assume that there are just four levels: the text level, the paragraph level, the sentence level, and the word level. In most of the discussion we will be occupied with only the first three levels. Separating the various steps in producing text structure helps the writer in two ways: it simultaneously eases the number of constraints that must be satisfied at one time and it increases the likelihood of satisfying any particular constraint.

Figure 5 shows a trace of these steps for a paragraph of this paper. The first box shows the major sections of the paper.

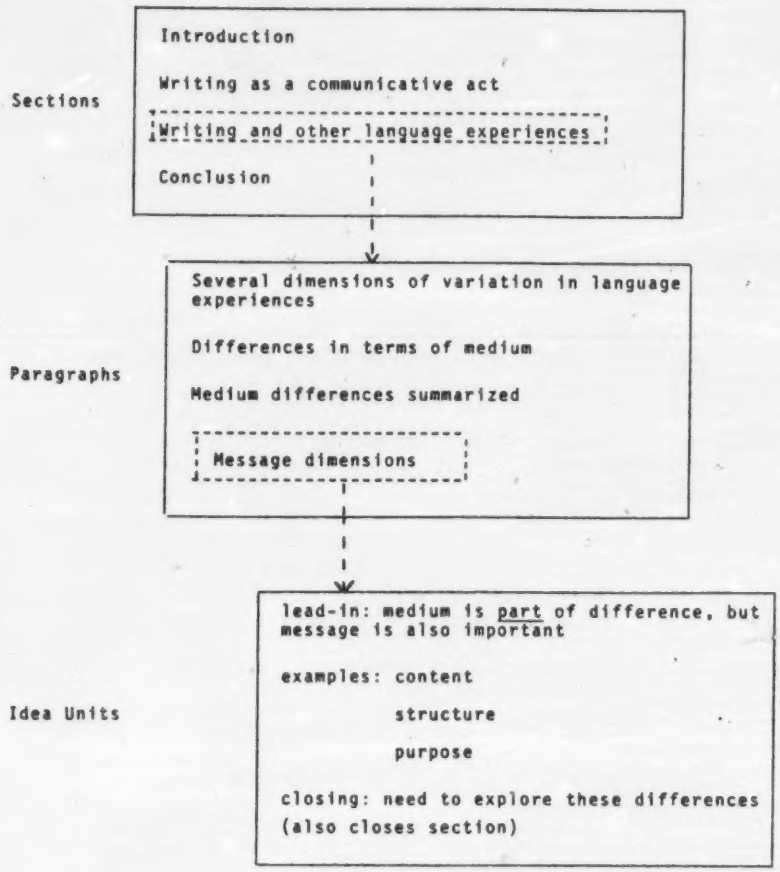

Fig. 5. Producing structures. The figure shows successive elaboration of the structure of this paper, from organization into sections to the internal structure of the paragraph that expresses the group shown in Figure 4.

Section 3 is then expanded into paragraphs. Finally, the last paragraph is expanded into idea units. Each of the idea units is expressed by one or more sentences, e.g., the lead-in:

> The disparity (as communicative media) between a child's typical oral conversation and writing accounts in part for difficulties in learning to write. But the experiences also differ in terms of message.

express the first idea unit:

> medium is part of difference, but message is also important.

The processes involved in producing text, whether they operate on the word level, the sentence level, the paragraph level, or the text level, must produce a linear sequence which satisfies certain grammatical rules and which simultaneously achieves important communicative goals. In order to spare the writer the process of simulating the reader at each step, certain devices and conventions have developed which reflect the results of the simulation. They represent, in essence, compiled wisdom. Some of these conventions are self-reinforcing; the more writers use "once upon a time" to begin a story, the more readers will come to expect that opening line and the more writers will cater to their expectations. The following section lists some textual devices which aid writers in the difficult task of finally producing a linear representation of their ideas.

Some of the research questions suggested by this view of generating structure are the following:

-What are the useful breakdowns of structure into levels (text, paragraph, sentence, etc.)

-What are the different ways people satisfy structure constraints?

-What are the most effective methods for satisfying structural constraints?

-How should transitions be handled?

-What is the relation between text forms (e.g., story or argument) and structural levels?

7. Devices for Text Production

The tacit goals of writing are realized by at least three different kinds of devices: structural devices, stylistic devices, and content devices. Sometimes a particular device serves several different goals; sometimes it may serve one objective, while interfering with another objective. In different types of texts, each of these goals may be more or less important. Therefore, it is essential to determine how different devices affect each of these goals, so that their use can be optimized to serve the specific goals of a particular text.

7.1 Structural Devices

The goals of communication can be achieved at different levels of text structure. At each level, there are specific forms that the writers can use to help fulfill those principles. We will describe structures at the text, paragraph, and sentence levels, bearing in mind that in longer texts there are often additional intermediate levels.

7.1.1 Text Level Devices

The following examples illustrate the kinds of text-level forms that occur in writing.

Pyramid Form: Any text can be structured so as to cover the most important ideas or events first, and then to fill in more and more detail on succeeding passes through the material. Stories are covered this way in newspapers, so that readers can stop at different levels of detail. This is also an effective structure for texts designed to teach, since it covers material in the order easiest to learn (Norman, 1973; Collins & Adams, 1977).

Story or Narrative Form: Any text can be structured according to the temporal and causal relations between the events that occurred. Story grammars (Rumelhart, 1975, 1977; Mandler & Johnson, 1977) attempt to give a formal characterization of story structure. Obviously most fiction uses some form of narrative structure, but it can be used in other forms of text as well. For example, a scientist may use narrative structure to describe what was thought and done in a temporal sequence as a story unfolding.

Argument Form: The Greeks developed several formulas for the structure of an oration. This kind of structure has been retained in part in the structure of such documents as legal briefs and scientific articles. One version of the form is the following: introduction, background, definition of issues, statement of what is to be proven, arguments for and against the

thesis, refutation of opposing arguments, and summation (Lanham, 1969). Argument form is designed to be persuasive and hence is really only appropriate for expository text.

Process-Of-Elimination Form: This is a kind of inverted pyramid structure where the writer makes an argument by eliminating all the possible alternatives (a form used, for instance, in Bailyn, 1967). It is a risky structure, because it means taking up the least important and least interesting points first. We mention it because in writing it is important to consider what structures are good and what bad for achieving different objectives. Process-of-elimination structure may be good for persuading the reader, but ineffective for holding his or her interest.

7.1.2 Paragraph Level Devices

Paragraph structures are as diverse as text structures. A common paragraph structure consists of the following: statement of thesis, elaboration of thesis, and summarization of thesis. In this scheme the elaboration can be realized many different ways: by giving an example, by supplying supportive evidence, etc. Other paragraph structures consist of an episode from a stream of events or a description of a scene or object.

7.1.3 Sentence Level Devices

Sentence structures are the most diverse of all, though some writers use only a small repertoire of sentence frames quite successfully. We describe briefly two sentence types that Strunk & White (1972) give as examples of tight and loose constructions.

(a) Because (old idea), (new idea).

("Because the store was closed, we went back home").

This is a tight construction, because it puts the given information in the first part of the sentence, the new information in the second part of the sentence, and links them in a strong way (Haviland & Clark, 1974). This construction therefore makes for ease of understanding and persuasiveness:

(b) (Idea 1), and (Idea 1).

("The store was closed and we went back home").

This is a loose construction which writers frequently overuse. In this construction there is no emphasis on the given-new distinction, nor does the conjunction specify how the two ideas are related. It is this very lack of specificity that permits its overuse.

7.2 Stylistic Devices

By stylistic devices, we refer to such elements in writing as contrast, rhetorical questions, humor, suspense, etc. We include here the use of pictures, though the placement is somewhat arbitrary. Like the structural forms, these stylistic devices exist at every level of text structure.

7.2.1 Use of pictures

Pictures have several properties that impact on different objectives of writing: (1) they tend to be attention getting and so can help to hold onto the reader long enough to get

information across, (2) they tend to be more memorable than text, (cf., Bower, 1972, Paivio, 1971) so that they are useful where forgetting is a major problem, and (3) they are able to communicate spatial ideas more easily than text, but generally are limited in what ideas they can communicate.

7.2.2 Use of contrast

Contrast generally serves to enhance the clarity of a text. It is particularly useful for juxtaposing correct interpretations or procedures with incorrect ones. It also generally acts to increase memorability, but can lead to later confusions when, for example, the reader cannot remember which interpretation is correct. Sorting out the effects of contrast on memorability would be one of our goals in specifying a theory of writing.

7.2.3 Humor

Humor is a device which can be very effective in achieving the communicative goal of holding the reader's interest. However, it may, by creating a less serious context, make it more difficult to achieve the goal of persuading the reader. This is a good example of the interactions that must be considered when using any of the devices; no device is uniformly effective for every purpose.

7.2.4 Suspense

Another important device for both narrative and expository text is suspense. In the most general way, suspense is created by communicating just enough (of an argument or a sequence of

actions) that the reader is induced to imagine a completion. The reader then becomes more active, hence more attentive, and, since he or she makes the conclusions, is more easily persuaded. However, suspense itself has a disadvantage, since it may make the text less comprehensible, if the reader cannot or does not complete the implied patterns.

7.3 Content Devices

There are three elements of the underlying idea structure of a text that have strong effects on its clarity and memorability. We refer to these as the hierarchical structure of the ideas, the tangibility of the ideas, and the connectivity of the ideas.

7.3.1 Hierarchical Structure

The surface form of a text is a linear structure, but underlying the linear structure is a higher level organization of ideas (Meyer, 1975). This underlying structure can be hierarchical to a greater or lesser degree. There is probably some optimum balance to achieve clarity and memorability; too flat a structure overloads one's ability to remember all the parallel elements. Too deep a structure overloads one's ability to remember all the levels of embedding, and to keep straight their interrelationships. Probably, a branching hierarchical structure with 3 to 6 elements at each branch is optimal (Mandler, 1967).

7.3.2 Tangibility of the Ideas

Ideas exist at all levels of abstraction in the hierarchy, from very global ideas pervading the text to very specific ideas realized in each sentence. Ideas at all levels can be more or less tangible. Tangibility involves such notions as how tightly or explicitly the idea is formulated. One way to make an idea more tangible is to name it. We are using this device here by assigning the word "tangibility" to the concept we are discussing. When an idea is named, it is then possible to attach different properties to it. This can make the text more memorable, but at the same time overuse of this device can make a text sound full of jargon and thus less comprehensible and persuasive.

7.3.3 Connectivity

The more explicit a writer can make the relationships between each new idea and the previous text, the easier it is for the reader to follow. Good writers have a large store of connective operators that can be used to indicate precisely where each new idea fits into the discourse structure. Examples are phrases such as "Accordingly," "In contrast," and "One implication of the above arguments." Such connective operators can even be used to cover up flaws in the content, resulting in polished but empty prose.

8. Good Structures - Editing

Most writers feel that editing is as crucial an aspect of good writing as idea and text production. Unfortunately, children have the intuition that once a text is generated, it is finished. Thus in teaching writing one major tactic is to teach students to step back and look at their writing from another person's point of view (Scardamalia, Bereiter, & McDonald, 1978). It may be useful to teach students some specific editing operators that skilled writers acquire after extensive practice in viewing their writing from the outside. In order to edit successfully, a writer must lift him or herself out of the text and assume the role of the imagined reader. Editing must be done to modify parts of the text which this reader would find lacking in comprehensibility, memorability, persuasiveness or enticingness.

Editing operators exist at each level of text structure. The editing operators for the most part parallel the structural devices discussed above, but they also reflect the kinds of corrections writers must make for typical errors. We list below some of the editing operators beginning writers should learn to apply.

Some text level operators are the following: (a) Delete extraneous material. Any sections of text that are not necessary, or that nothing else in the text depends on, should probably be deleted. (b) Add headings and plan of text. Anything done to make the structure of the text more visible helps the reader. (c) Move important ideas to the front. If the most

interesting or important ideas are buried in the middle of the text, the reader may never find them. (d) Qualify at beginning, not in each sentence. If there is a need to qualify the certainty of a whole section of text, move all the qualifications into a general statement at the beginning.

Some paragraph level operators are the following: (a) Split long paragraphs into two. Except in narrative text, long paragraphs are exhausting to read and hard to remember, so the writer should shorten them where possible. (b) Make lists or tables. Where a paragraph is discussing a whole series of ideas, it helps the reader if the writer puts them into lists or tables where the parallel structure is apparent. (c) Add topic and concluding sentences. Paragraphs that do not start with a topic sentence or conclude with a summary sentence can often be improved. (d) Put in connective phrases. Very often phrases like "therefore" and "nevertheless" can make clear the relation between different ideas in the paragraph.

Some sentence level operators are the following: (a) Delete empty words and phrases. There are a number of words and phrases that creep into text and can be deleted, such as "seems to be", adverbial modifiers, alternatives in "and" and "or" constructions. (b) Create parallel structures. Often sentences are difficult to understand because parallel structure is not maintained in different clauses or phrases. (c) Break long sentences into shorter sentences. If a sentence is too long, it helps to make two sentences out of the one, as is almost always possible. (d) Turn passive sentences into active sentences.

Passive sentences often lead to awkward constructions, which a change to active voice can eliminate.

Using these and other editing operators, a good procedure for text production becomes:

1. Create a detailed outline of the text structure.
2. Apply text-level editing operators.
3. Create a semi-text with all the ideas included in paragraphs, but not in finished sentences.
4. Apply paragraph-level editing operators.
5. Create finished text.
6. Apply sentence-level editing operators.

This step by step approach helps the writer because he or she can edit at several levels before producing finished text. It also allows concentration on generation and editing with respect to one aspect of the text at a time, thus helping to overcome writer's block.

Editing is one of the most important tasks a writer must perform. It is not a subprocess in itself, but rather a re-application of subprocesses to partially finished products. With respect to idea discovery the editing process helps in choosing the most interesting and relevant ideas, as well as in clarifying, redefining, extending, or constraining ideas formulated initially. With respect to manipulating ideas, it may lead to re-structuring groups or to re-defining the relations that hold ideas together. With respect to structure, it helps by refining the match between the structure produced and structural

constraints. This view of editing suggests several research questions:

-What are the strategies for editing?

-What conditions trigger different writers to edit?

-What is the relation of criticism to editing?

-What is the relation of self-criticism to editing?

-How can purpose constraints be applied during editing?

9. What Makes Writing Difficult to Learn?

Much of the difficulty of writing stems from the large number of constraints that must be satisfied at the same time. In expressing an idea the writer must consider at least four structural levels: overall text structure, paragraph structure, sentence structure, and word structure. Clearly the attempt to coordinate all these requirements is a staggering job. What makes the learning process particularly difficult, however, is that the whole set of task components must be learned at once. The child has no opportunity to set aside the problems of spelling and syntax while learning to produce paragraph structures. The teaching methods we propose in the next section are designed to allow the beginning writer to concentrate on a subset of the task, while still performing a communicative act.

One great difficulty for novice writers is maintaining connective flow. The relationships between ideas must be made clear. Yet in order to write about an idea, the idea must be expanded downward in terms of the successively lower levels of paragraphs, sentences, words, and letters. This requires a great

many processes, most of which are irrelevant to the connection between the two ideas. Having produced an expansion of the first idea, the writer must jump back up to the idea level to recall the desired connection, and then produce a similarly detailed expansion of the second idea, together with an indication of the relationship between the two ideas. It is here that many writers experience most of their difficulties.

Sometimes writers, particularly children, become lost in the process of downward expansion and lose sight of the high-level relationships they originally wanted to express. Down-sliding - the phenomenon of getting pulled into lower and more local levels of task processing - is a very common problem in writing, and in other domains as well. In writing (and reading), educational practice has reinforced the natural tendency towards down-sliding, with the result that many children focus almost exclusively on lower-level task components when they write.

Scardamalia's (in press) observations of children's prose illustrate their difficulties in maintaining connective flow. She gives many examples in which idea-level relationships are inadequately expressed, even though the lower-level structures of syntax and spelling are quite good. The developmental increase in the number of ideas that can be coordinated probably reflects the fact that older children are more practiced at text production. This means that the lower levels of structure no longer occupy all their attention, allowing them to spend more resources coordinating ideas.

10. Intermediate Tasks

Our analysis of the writing process suggests different ways it can be fractionated to ease the number of constraints that must be satisfied at any one time. Our earlier comparison of the production of oral and written language suggests where children who have acquired oral skills may have problems in learning writing skills. This comparison in turn suggests a number of intermediate tasks that children might be given to exercise the different subskills needed for writing.

10.1 Discovering Ideas Tasks

Some of the intermediate tasks for discovering ideas are the following: (a) Work together at collecting ideas, (b) Keep a journal (this is an old but effective task that helps both beginners and expert writers), (c) Discuss each other's ideas as a group.

10.2 Manipulating Ideas Tasks

For manipulating ideas, some of the following intermediate tasks suggest themselves: (a) Take a set of ideas and make explicit comparisons and contrasts among the ideas, (b) Put given ideas into a hierarchical structure, (c) Decide among given ideas which are most relevant to some purpose.

10.3 Producing Text Tasks

The basic idea of the text generation tasks is to simplify the writing experience by having the child perform only part of the task of writing. The parts of the task left to the child can

be progressively varied from simple to complex. A student can be asked to write one level of a passage under conditions such that all other levels of text structure are managed by the teacher. At each level of structure, a student can be given pieces that make up the next level and asked to arrange them in a coherent whole. For example, at the text-structure level, he or she would receive a collection of paragraphs to order into a text. At the paragraph level, sentences would be given, and so on. In most cases these pieces will be slightly rough, and in particular they will lack the appropriate connective phrases. The student's job is to provide connections between the pieces, as well as to order the pieces.

Another intermediate task is to take a given set of ideas and put them into one of the structural forms, e.g., the pyramid form. Next, the filled-out form is judged by peers in terms of, not its correctness, but its comprehensibility, memorability, enticingness, and persuasiveness. Such a task allows the beginning writer to focus on text structure as a skill to be learned, but does not destroy the communicative purpose of writing.

10.4 Editing Tasks

Another way to subdivide the writing process is to give students a text to work on that needs editing. A few variations of this idea are the following: (a) The single-level task. The first and simplest task is for the person to edit on only one level of text structure, given a specially prepared text with

errors only on that level. (b) The sequential-levels task. The second task is for the person to edit on one level when given a text with errors on several levels (a simulated first-draft). (c) The multiple-levels task. This task also uses a first-draft text with errors on several levels,but in this task the person must edit on all the levels, instead of just one.

The single-level task provides a simplified arena in which to discover how well a person understands rules at a given level of structure. It allows the student to set aside the problems of attention-sharing among various tasks. In addition, a person's accuracy on the single-level task can be compared with accuracy on the other two tasks. This comparison provides an insight into how well the person can use understanding of a given level in a more complex naturalistic context.

A particularly interesting comparison is that between a person's performance on a given level in the multiple-levels task, and performance on that same level in the single-level task. This comparison provides a measure of which levels suffer most when attention is divided among several levels. When a novice writer has to deal with more than one level at once, the view of writing as fulfilling multiple constraints suggests that editing will be less accurate than when only one level is involved. More specifically, a beginner's tendency to down-slide suggests that the novice, when given more than one level to deal with, will focus on the lowest ones. This means that performance on the lowest of several levels will be more like single-task performance than performance on the high level. Performance on the highest levels will suffer most in a multiple-levels task.

10.5 Self-Editing Tasks

Some interesting manipulations in the editing task can be performed using a person's own writing. The simplest version of the task is simply to show or read a piece written by the student and ask how well it achieves its intention and how it can be improved. To the degree that a person detects problems and suggests improvements on a given level, we can infer understanding of the structures for that level. A person's ability, however, to identify problems explicitly may lag behind implicit knowledge of the area. Many instances of this kind of gap are reported in the developmental literature; for example, Gleitman, Gleitman and Shipley (1972) and de Villiers and de Villiers (1974) have found that young children can identify sentences as semantically and syntactically anomalous before they are able to correct them. People often can differentiate good writing from bad writing even when they cannot themselves produce good writing. This suggests a set of tasks that exercise a person's knowledge about what constitutes good structure in writing. For these tasks the student's own text is altered in various ways and then the student is asked to rate the goodness of the writing.

The basic procedure is as follows: First, the child writes a passage on an assigned topic; second, the teacher produces one or more altered versions of the child's passage; third, the child is shown the altered passages as well as the original (but retyped) passage and is asked to rate the passages for goodness of writing and for effectiveness at conveying the writer's

intent. Alterations can be made at any of the structural levels of text, and also in the content. Both improvements and degradations of the text could be included. Further, alterations can vary in extent, from total reorganizations of the material to simple editorial changes.

One intriguing question is the extent to which people prefer alterations over their own original versions. Informal observations of ourselves and other writers suggest that people often prefer prose in which corrections have been made. If the ideas are better organized, if appropriate connectives are added, or if the syntax is corrected, students are likely to prefer an altered version to their own original. This intuition seems obvious, but it has important implications. The extent to which a person prefers an alteration over his or her own prose, when asked to rate several variations, is a measure of the gap between the person's implicit knowledge about what constitutes good text and the knowledge explicitly accessible to that person during construction of prose. The systematic description of the kinds of alterations that a person is sensitive to provides a window into knowledge that would otherwise be inaccessible to the outside observer.

11. Conclusion

Analyses of the writing process are not new; writers, literary analysts and rhetoricians have all contributed useful insights. However, their contributions have not in general been explicit enough to form a scientific basis for analyzing writing

skills. The formalisms we are exploring come from cognitive science, and hence, historically from theoretical linguistics and artificial intelligence. They are built on notions such as, "debugging" (Brown, Burton & Hausmann, 1977); "successive refinement" (Minsky, 1962), and "constraint satisfaction" (Woods, 1976). Many of these notions arise from the computer metaphor, which says, not that writing (or thinking) is a mechanical process, but that the language used for describing computer processes is the richest one available for expressing process theories in precise forms.

The definition of a series of steps is only part of the specification of a process model for writing. Equally important are considerations of timing and interactions among the subprocesses, i.e., the control structure issue (Nash-Webber and Bruce, 1976). Some of the control structure questions that need to be addressed are the following:

-What strategies do writers have for determining which process to work on?

-How does a writer decide that the output of one process in sufficient for a succeeding process to take over, e.g., that ideas have been grouped together well enough for text structure to be generated?

-How does a writer decide to redo a process e.g., to reformulate an idea or rewrite a paragraph?.

The cognitive science approach to writing, then, is not a unified theory but, in the terminology of our discussion, a device for generating ideas. The questions listed here derive

from that approach; answers to them would be at least a step toward a more complete theory of the process of writing.

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